

ASSESSING THE EFFECTS OF RAINFALL VARIABILITY ON PLANTING DATES FOR MAIZE PRODUCTION IN SALIMA

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ABSTRACT

This study was done to assess the effects of rainfall variability on planting dates. It was done in Chipoka Extension Planning Area (EPA), Traditional Authority Ndindi in Salima district, central region of Malawi. Daily rainfall data for Salima district was analysed to come up with planting dates. The analysis was done using Instat+ version 3.37. To do this, the study used a definition of planting date as the first occasion from 1 November with 25mm rainfall or more, within a period of 3 days with no dry spell of 9 days or longer within the subsequent 21 days with a threshold value of 1mm. Results showed that the mean planting date for rainfed maize crops in Salima is 9 December with a standard deviation of 9 days. The normal planting period is between 30 November and 18 December. Variability of rainfall and planting dates was found to be minimal and the years in which planting was done very late were the years of El Nino or La Nina events. Climate change has various impacts on stability of weather elements such as precipitation and temperature. Owing to the same, rainfall variability has become an issue in rainfed agriculture in countries like Malawi where farming is the main way of making a living. This is so because agriculture depends on reliable weather patterns and it is a sector that employs a majority. The principal occupation of about 85% of Malawians is agriculture. Rainfall season in Malawi occurs during the warm-wet or summer season in the months of November to April. So, planting is done in November or December depending on the start of rainy season. The main rain bearing system during this time is Inter-Tropical convergence zone (ITCZ) which oscillates over Malawi from southern region, slowly to the central and northern regions making start of rains early in the southern region than the central and northern regions of Malawi. Therefore, planting dates are early in southern region. Another rain bearing system is congo air boundary. Having knowledge of planting dates can help farmers in planning for their farm operations including planting at the right time and avert the risk of early season dry spells.

DEDICATION

To my aunt, Mercy P. Zulani

For her deep love and kindness to me.

Your encouragement really pushed me forward, it was a source of persistence that helped me to go on with my studies until I finished.

This work is duly dedicated. Stay blessed.

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I would like to acknowledge Mr. Trywel Bwanali, health assistant at Salima district hospital (DHO), for providing me with encouragement and even financial support throughout my studies at Malawi University of Science and Technology. May the almighty God bless you; I love you so much.

Another special acknowledgement goes to my supervisor, Dr. Matthew Fulakeza, for his support and guidance that helped to make this work perfect and successful. He was not hesitating to help whenever I sought his assistance. May you keep it up, my coach my master.

More importantly, my gratitude to Almighty God for His unconditional love and wisdom He gives me in whatever I do. He is always there for me fighting all my battles. He is indeed the way maker and this work is my testimony.

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LIST OF ACRONYMS AND ABBREVIATIONS

DCCMS Department of Climate Change and Meteorological Services

ITCZ Inter-Tropical Convergence Zone

ENSO El Nino Southern Oscillation

GoM Government of Malawi

CAB Congo Air Boundary

EPA Extension planning area

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CHAPTER ONE

GENERAL INTRODUCTION

1.0. Background of the study

Climate change has a variety of consequences for people's livelihoods. In a developing country like Malawi, the effects of climate change are most noticeable in the agriculture sector, which is one of the most vulnerable economic sectors to the effects of climate change (Maina et al., 2015). Farmers (Simelton et al., 2011) are particularly affected, as they rely on predictable weather patterns for their livelihood. These predictable weather patterns include normal precipitation and consistent temperatures. Because agriculture employs the majority of Malawi's population, climate change is a big concern. The primary occupation of 85 percent of Malawians is agriculture. These factors are essential for defining climatic change, as well as being the most important need for plant growth. In order to grow, different crops require different temperatures and amounts of rainfall. The world is witnessing rising temperatures and rainfall variability as a result of climate change. Temperature is the most independent weather variable, determining other weather factors such as precipitation. Rainfall is becoming increasingly unpredictable as a result of the rise in temperature caused by the accumulation of greenhouse gases (carbon dioxide, methane). Because high temperatures accelerate evaporation (Brook, 2015), more water evaporates into the sky, resulting in heavy precipitation. Variability in rainfall has an impact on when planting takes place. According to current climate change studies, there has been unpredictable rainfall and late commencement of rainfall in recent years (Study and District, 2010; Sutcliffe et al., 2016). Climate change is producing a shift in planting dates and a decrease in growing season duration. The goal of this study is to see how planting dates in rainfed agriculture have changed throughout time. Variability in rainfall and planting dates are two variables that are directly linked. Any changes in the commencement of the rainy season have a direct impact on the time of planting in rainfed agriculture. Salima is one of the districts located along lake Malawi in the central region of Malawi. Being along the lake, its weather is also influenced by temperatures of

water in the lake which makes it a bit different from many other districts that are not along the lake. There have not been many studies that were conducted to evaluate how planting dates are affected by rainfall variability in this area. This research was done to fill the gap of knowledge that existed in terms of shift in planting dates. It was very difficult to have successful planting due to early season dry spells, and that is a challenge many people were facing when it comes to time for planting. All this was due to rainfall variability and farmers were unable to time planting correctly which was resulting in replanting of maize seeds due to failed germination among many people involved in rainfed agriculture. In this study, an average planting date was calculated.

1.1. Problem statement

Rainfall variability has devastating effects on agriculture. The rainy season starts in late November or December and finishes in March with some dry spells in the early days after the rainy season starts before coming to normal amidst the month of January (Study and District, 2010), while in the past planting dates used to be in early November and rainfall was falling in adequate amounts for plant growth till in April. Malawi's economy being agro-based is negatively affected by this rainfall variability which is shifting planting dates and reducing rainfall duration. Erratic rainfall hinders agricultural development and needs to be taken carefully by finding alternative ways of generating food to ensure food security and better Malawi. Agriculture accounts for 37% of gross domestic product (GDP) and 85% of export revenues that bring foreign currency to Malawi (Kazembe, 2014). The failure of agricultural production, therefore, has great implications on the countrywide state of the economy and to the survival of farmers who also depend on farm produce for food and source of income to buy their basic needs after selling (Msowoya, 2013). Minimizing overdependence on rainfed agriculture and embarking on other agriculture systems can be of more benefit to increase yield per year. Shift of planting dates is forcing farmers to opt for expensive hybrid maize varieties which mature within 90 days (Asfaw et al., 2014; Msowoya, 2013; Study and District, 2010). This is increasing the cost of production since the hybrid

varieties require excessive use of chemical fertilizers as opposed to local maize varieties. Rainfall variability is also associated with early season dry spells which occur due to the false start of rainy season. This results in resowing or poor growth of maize since the planted seeds lack enough moisture for their development (Practices, n.d.). Resowing also increases the cost of production.

1.2. Study objectives

The objectives of the study were developed with an aim of answering research questions stated in 1.3.

1.2.1. Main objective

The main objective of this study was to find out the effects of rainfall variability on planting dates for maize production in rainfed agriculture in Salima.

1.2.2. Specific objectives

i. To evaluate the changes in planting dates for Chipoka area in Salima district from 1991 to 2020.

ii. Evaluating the average period planting is done in Salima.

iii. Finding out if variation in planting dates happens periodically.

1.3. Research questions

- Is there any shift in planting dates that has occurred due to climate change?
- To what extent have planting dates shifted in Chipoka?

1.3.1. Research hypothesis

- H0: There is a shift in planting dates in Salima.
- H1: There is no shift in planting dates in Salima.

1.4. Significance of study

The study outcomes are beneficial to farmers and Malawi as a nation in the following ways

- An individual who wants to open a farm in Salima can use the findings to know the month planting is done in Salima district, central region of Malawi.
- Socio-economic activities such as agriculture depends on climate and more especially rainfall (Tadross et al., 2009). Shift in planting dates which can imply dry spell is a major climatic challenge and has major implications on the livelihoods of people in the rural areas. Knowing specific time for planting can help to avert the risk of dry spells that occurs when planting is done during false start of rainfall. It is better to know the appropriate time the true start of rainy season likely occurs.
- Knowing planting dates helps in decision making. An individual can make proper plans regarding when to get seasonal weather to act as a guide in planning for farm operations. One can make efficient use of resources to make sure that everything is ready for planting when true start of rainfall occurs.
- Establishing rainfall and temperature trends of an agricultural area helps communities in the area to increase their livelihoods through resilience of rainfall variability and adaptation by changing their farming practices (Maina et al., 2015)

CHAPTER 2

LITERATURE REVIEW

Agriculture production has declined over the last few decades as a result of irregular rainfall, with rain falling for shorter periods of time and in lesser amounts. Extreme disasters, such as flash floods, are some of the elements contributing to agriculture's decline (Msowoya, 2013). The onset of rainfall is critical in determining shifts in planting dates (Simelton et al., 2011) and is the most important predictor of planting time.

Tadross et al., (2009), also conducted a research to find out the effect of variation in growing season rainfall on planting dates. They observed changes in daily rainfall records. Rainfall indices such as frequency and intensity were developed to represent planting

dates. They used definition of planting date as period when there is 25mm of accumulated rainfall in 10 days, without 10 consecutive dry days (rainfall less than 2mm) occurring in the next 20 days. To prevent missing data from introducing false trends in the rainfall indices the following were done:

I. Planting and cessation indices were set to undefined if any missing data was encountered.
II. All other indices were calculated if planting dates were defined.

The most important aspect that was used is the start of rainfall sufficient for planting (which is assumed as the planting date). The observed limitation to this study is that the study used a definition which rarely offered greater than 50% probability of sufficient seasonal duration for non-early maturing varieties like local maize. So it was not a realistic planting criterion (Tadross et al., 2009). The current study used a definition of planting date as the period when there is 25mm accumulated rainfall on a single day or totaled for three days with dry spells not exceeding 9 days within the following 21 days with a threshold value of 1mm after 1 November.

2.1. Rainfall season of Malawi and rain bearing systems

Malawi experiences three main seasons which are warm and wet season (November to April), hot and dry season (September to October) and cool and dry season (May to August) (Plan, 1978). These seasons are generally classified into dry and wet according to climate of Malawi which is tropical wet and dry or savanna climate. The wet season occurs between November and April and the dry season occurs between May and October (GoM, 2017). Rainfall season in Malawi is experienced in the warm and wet or summer season.

The main rainy season in Malawi is from the month of November to April (Kazembe, 2014; Ngongondo et al., 2011). This rainfall season starts differently in the three regions of Malawi. It starts early in the southern region, then at the central region and progresses to the northern region (Gibson et al., 2017). This is so because of movement of inter-tropical convergence zone (ITCZ) which is the main rain bearing system in Malawi

(Kazembe, 2014). The ITCZ is marked by the convergence of northeasterly monsoon of northern hemisphere and southeasterly trade winds of southern hemisphere (Ngongondo et al., 2011). It is a low-pressure belt which oscillates over Malawi in December, January and February. It moves to southern Malawi around November or December and settles there for a while and starts moving northwards slowly to central region and then northern region. It tends to follow the sun's zenith position. Solar heating in the ITCZ region causes air to rise by convection, resulting in precipitation. This helps to explain why rainfall begins early in Malawi's southern region and late in its northern part. As a result, maize planting in rainfed agriculture occurs earlier in Malawi's southern region than in the central and northern regions.

The northwest monsoon, commonly known as the Congo Air Boundary (CAB), is another key rain-bearing system that adds to Malawi's rainfall season (Ngongondo et al., 2011). The Congo air boundary separates the monsoon systems of the Indian and Atlantic oceans (Konecky et al., 2011). The meeting point or confluence of Indian Ocean southwest trade winds and recurved south Atlantic air is marked by this boundary (Kazembe, 2014; Tadeyo et al., 2020). This air mass passes through the Congo basin in the Democratic Republic of Congo on its way to Malawi (Kazembe, 2014). A tropical cyclone can sometimes form in the Indian Ocean and cause dry or wet spells depending on its location in the Indian Ocean.

2.2. Possible causes of rainfall variability and delayed planting

Seasonal rains in Malawi are determined by two factors. The first is the location of the intertropical convergence zone, ITCZ, and the second is the temperature of the Indian Ocean's sea surface (*Rainfall Variation and Food Security in Malawi, 2018*).

El Nino southern oscillation phenomenon (ENSO) has a major impact on inter-annual rainfall variability (GoM, 2017). The El Nino southern oscillation phenomenon causes variations in the Indian Ocean's sea surface temperature, which in turn causes variations in rainfall carried by the ocean to Malawi.

During El Nino, trade winds along the equator are weaker than usual, allowing warm water to accumulate along the eastern Pacific and warm surface water to warm the atmosphere, causing moisture-laden air to rise and form rainstorms (Mcphaden et al., n.d.). This makes the Eastern equatorial Africa receive above average rainfall in El Nino conditions while south-eastern Africa, Malawi inclusive, tends to experience below average rainfall (Mcsweeney et al., n.d.). The opposite phenomenon to El Nino is La Nina. This is unusual cooling of water over the Eastern and Central Equatorial pacific ocean (Gibson et al., 2017). It happens when the trade winds in the equatorial eastern Pacific are stronger than normal, resulting in low ocean surface temperatures. In La Nina conditions, the atmosphere cools as the ocean surface cools, resulting in less water evaporation and rainfall. In that case, weather pattern opposite to El Nino occurs (Mcphaden et al., n.d.; Mcsweeney et al., n.d.). Less rain falls over the eastern pacific while south-eastern Africa, including Malawi, receives above normal rainfall. These oscillations are powerful forces to the extent that they can cause a shift in seasonal temperature and precipitation (Niño and Niña, 2018). The resulting shifts in seasonal temperature and precipitation are known as teleconnections. The term teleconnections refer to El Nino southern oscillation (ENSO) effects which emphasize that changing conditions in one part of the world can also affect some areas far from the source. Warming and cooling of different parts of tropical ocean and shift of pressure gradients cause a shift in atmospheric wind patterns which alter precipitation patterns (Niño and Niña, 2018). The movement and location of ITCZ also affect rainfall onset since it does not follow a fixed pattern (GoM, 2017). It might delay or start earlier than expected.

2.3. Evidence supporting the claim that rainfall variability affects planting dates

A study about community experiences with climate change (case study of Salima district) assessed changes in seasonal rainfall pattern, daily rainfall and planting data sets were used to find out if there was any sign of a shift in planting dates. The study analysis used a definition of the start of rainy season as the first occasion with more than 20mm in 2-day period after 1 November and 1 December with dry spells not exceeding 8 days in the

next 30 days. Data for planting dates was analysed to observe the changes by plotting a graph of the data. Figure 1a and 1b below shows the resulting graphs.

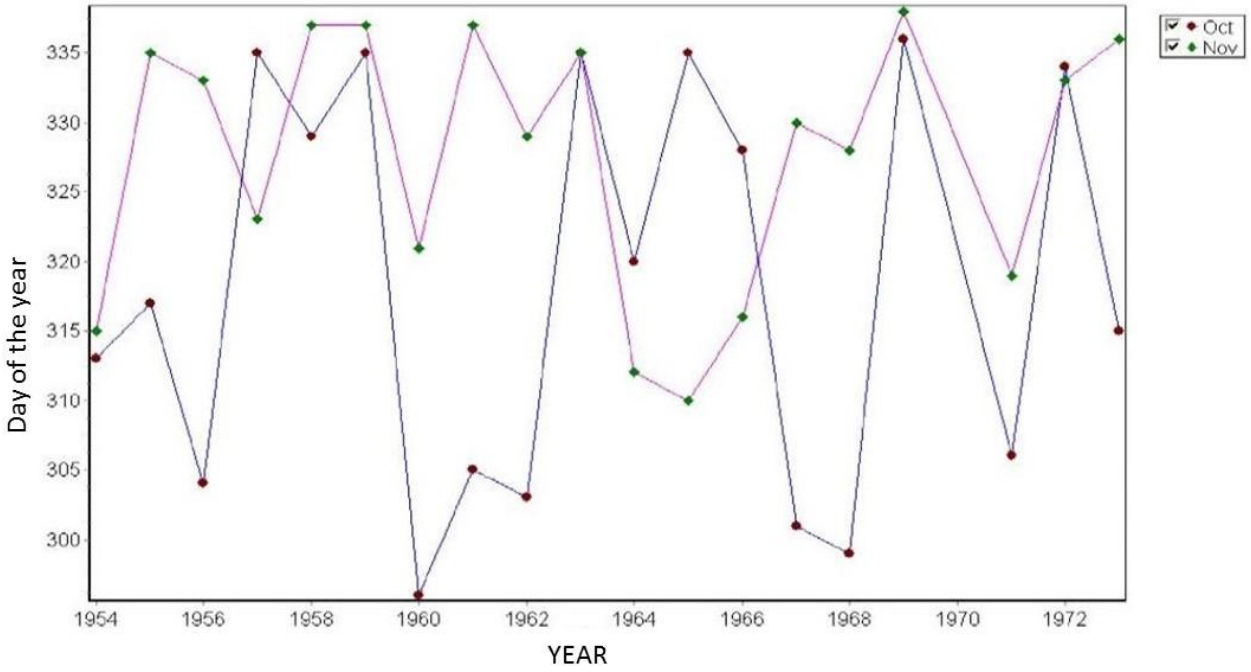


Figure 1a: Possible planting dates between 1954 – 1972 in months of October and November

Source: *Case study of Salima; March, 2010.*

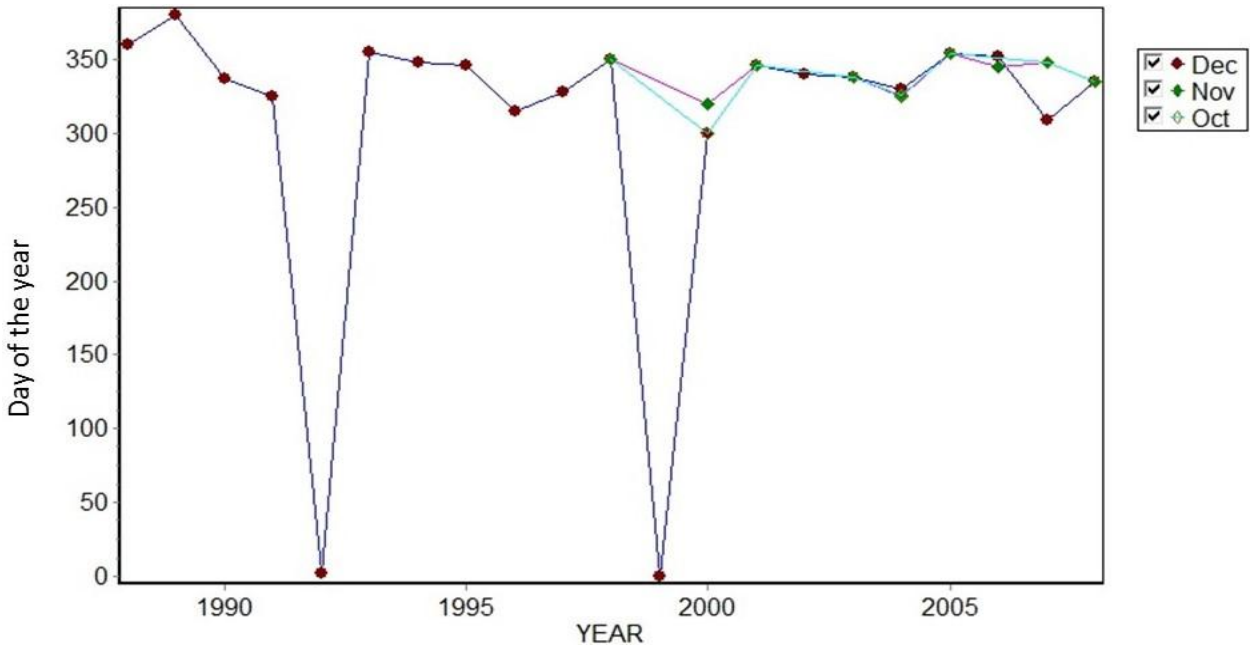


Figure 1b: Possible planting dates between 1988-2008 in months of October, November and December

Source: *Case study of Salima; March, 2010.*

The study results from figure 1 above showed that during 1954-1972 period there was a 38% chance of successful planting in October and almost 100% chance of successful planting if done in November. Results in figure 1b (1988-2008), showed that there was no chance of successful planting in October and just 26% of successful planting in November and 100% successful planting could be done in December. On some occasions, planting was delayed until January (Study and District, 2010). So, it was interpreted that planting dates have shifted from October to December in Salima district. Communities that were visited in this study are Mphunga and Kandulu villages of Traditional Authority Ndindi and some villages in Traditional Authority Maganga. This research aims to extend this work to evaluate the shift between a period of 1991-2020. A conclusion will be drawn from the results to say that there is still a shift or the planting dates have stabilized now, such that there is no significant shift of planting dates in recent years.

Sutcliffe et al., (2016), conducted a research in Kasungu and Ngabu about evidence and perceptions of rainfall change in Malawi. One of the criteria used to sample study villages in these areas was nearness to weather station. They collected daily rainfall data sets from 1961-2011 for analysis. Rainy season onset was defined as the first instance when more than 25mm of rainfall has accumulated over a period of 10 consecutive days, without any period of ten consecutive dry days. The end of the season was defined as the point when three consecutive 10-day periods received rainfall less than 20mm each. Results showed that many participants from the two sites perceived later onset of the rainy season which implies a delay in experiencing planting dates for their crops.

2.4. Impacts of shift in planting dates

The study which was conducted in Kasungu showed that rainfall pattern is changing. They would expect rain to start in October or November but the rains were starting in December. Thirty years then, the rains would come in October. But the rains used to

come late (Sutcliffe et al., 2016). This made it harder for people to have a successful maize crop. This might be the case because any delay in planting date is associated with short length of a growing season such that crops are deprived of rainfall in their maturity stage. This is supported by the idea that the relationship between total seasonal rainfall and maize yield is a character of the start of rains and dry spells, and the impact of rainfall variability on crop production is clearly tied to the planting date (Tadross et al., 2009).

CHAPTER 3

METHODOLOGY

Catherine Dawson (2002), defines methodology as the philosophy and general principle which guides the research. This is the section that outlines the steps and procedures or research methods that will be followed to achieve the research goals. It is divided into subparts namely: research design, study area, data collection and data analysis.

3.1. Research design

This is a plan and structure of investigation that was used to find relevant answers to research questions. The study employed quantitative research design to conduct the research. This involved analysis of daily rainfall data to come up with data for planting dates. Data for planting dates was used to come up with a vivid evidence that there is a shift in planting dates or not.

3.2. Study area

The study was done in Traditional Authority Ndindi, Salima district at Chipoka area in central region of Malawi. This site is surrounded by some areas such as Lifidzi which is to the North of this site, Mchoka area to the South East, Chimoga village to the west and Chapita to the North. This site was chosen as researcher's interest because farmers of this area had been having difficulties with their farming activities due to shift in planting dates that results in decreased growing season, the only people that were able to thrive well are those who adopted early maturing hybrid seeds in their farming. Besides that, there was a study which was conducted in that study area relating to the same topic, 'impacts

of rainfall variability on planting dates. The results of that study concluded that planting dates shifted from October to December in Salima (Study and District, 2010). Researcher's desire was to compare the results to those of that study which acted as a hypothesis to the current study. The following map shows the study area

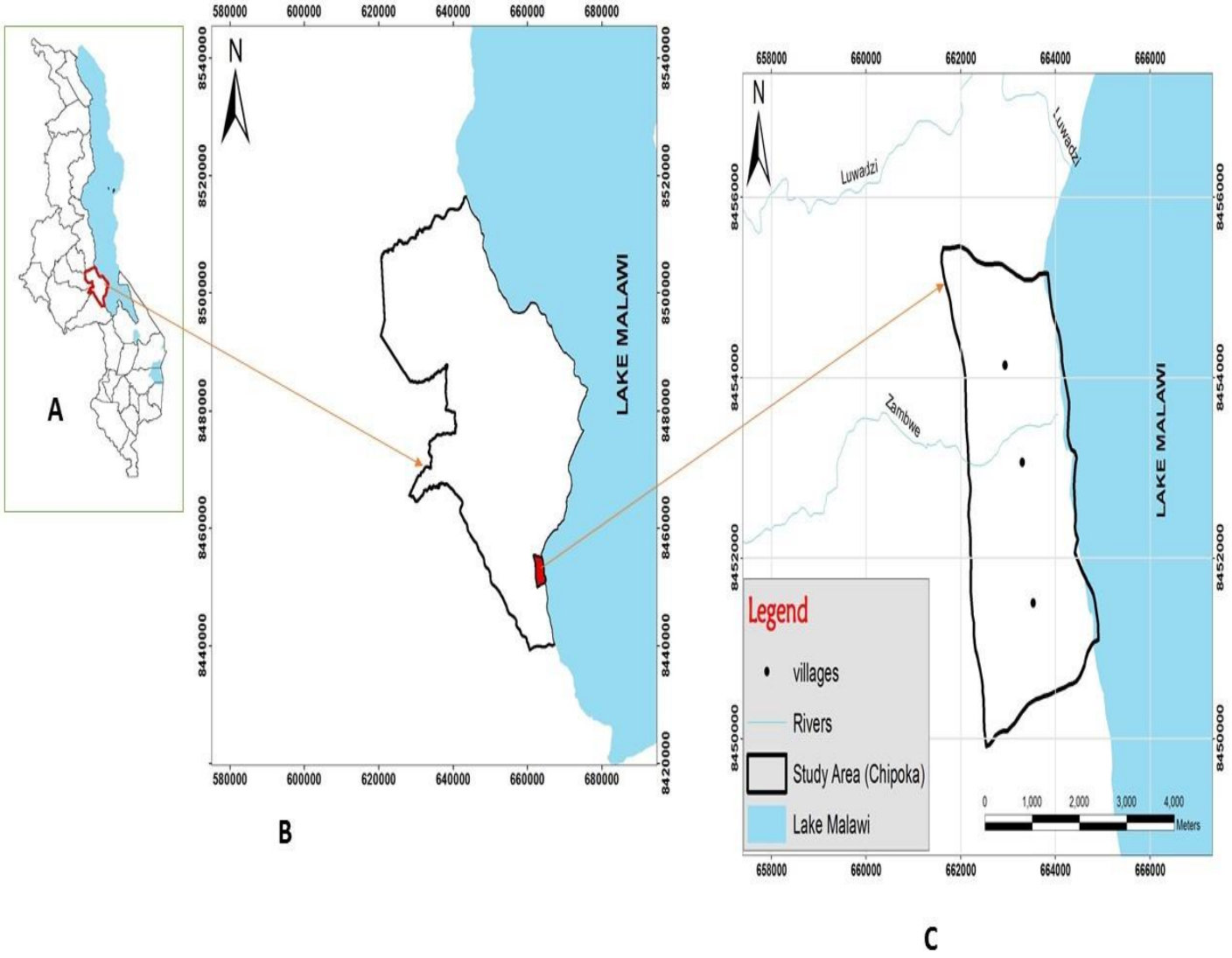


Figure 2: Map of study area; Chipoka in Salima district, central region of Malawi.

A is the map of Malawi

B is the map of Salima

C is the map of Chipoka EPA (study area)

3.3. Data collection and management

The study used daily rainfall data for Salima district as secondary data. From the rainfall data planting dates were calculated upon which analysis of any shift related to rainfall variability was done. The data was collected from meteorological department of Malawi and then it was organized in an excel sheet 2016 into a format supported by Instat plus software. Analysis using Instat plus software package was finally done by plotting graphs to show the shift in planting dates. After that, it was tabulated to show the planting date against each year and rainfall amounts that triggered planting measured in millimeters. Instat software is a statistical program which was developed in United Kingdom by the University of Reading in 2002. The data was quality assured since it was obtained from the Department of Climate Change and Meteorological Services (DCCMS) of Malawi. At the DCCMS the data is quality controlled before it is entered into the rainfall database. The actual data for planting dates was obtained from Chipoka EPA for the purpose of ground truthing (process of confirming or validating data obtained indirectly by direct observation on the ground). This was done to have a picture of how erroneous are the generated planting dates.

3.4. Data analysis

Daily rainfall data for Salima district from 1991-2020 was used to come up with planting dates of years in the aforementioned period. The analysis used a definition of planting date as the first occasion from 1 November with 25mm rainfall or more, within a period of 3 days with no dry spell of 9 days or longer within the subsequent 21 days with a threshold value of 1mm. The condition for a dry spell not exceeding 9 days was considered to make sure that that planting date enables successful planting by avoiding the risk of maize seeds failing to germinate due to lack of sufficient soil moisture during the period of dry spells. These planting dates were generated using Instat+ software package version 3.37. The proposed definition was borrowed from the definition of DCCMS for rainfall onset and the start of rainfall season. The definition fits to be used for planting date since planting is done once sufficient rainfall for seed germination is received within any day or days in the warm-wet season which starts from November to

April. Hence, planting in rainfed agriculture is done in months of November, December or January during late onset of seasonal rains.

3.4.1. Analysis of change in planting dates

To find out the effect of rainfall variability on planting dates, a line graph of the year against its planting date was plotted. The data was divided into two datasets to avoid overloading of information on the same graph. Each dataset comprised 15 years, the first one from 1991-2005 and the second one from 2006-2020. In that case, there was two graphs to make the graph plots clear. From the graphs a conclusion was drawn to say whether there is a significant shift in planting dates or not. This achieved the main objective 1.2.1 and the first specific objective in 1.2.2.

3.4.2. Calculation of average period of planting date

The average planting date was calculated by summing up all the planting dates and divide the sum by the number of years as illustrated below

$$\text{Average planting date} = \frac{\text{Sum of all planting dates (N) during the period of study}}{\text{Number of years (n)}}$$

$$= \frac{\Sigma N}{n}$$

This was done to find a day planting took place on average and it helped to achieve specific objective number 1.2.2.iii. For this study number of years covered was 30, and therefore; n was equal to 30.

3.4.3. Analysis for periodic trend of planting dates

To find out if the variation in planting dates happens periodically as was stated in the third specific objective in section 1.2.2. A judgement was made by visualization from the plotted graphs to say whether the planting dates closely repeat themselves after some years. This stated whether the variation follows a certain pattern or it just happen without any defined pattern. As for El Nino event which causes low average rainfall in Malawi occurs roughly every three to seven years (Mcphaden et al., n.d.).

CHAPTER 4

RESULTS AND DISCUSSION

In this section, results that were obtained using the methodology described in chapter 3 are presented. These results are presented graphically and also tabulated to enhance understanding of any changes that were happening in planting dates over the years.

4.1. Results for changes in planting dates

Daily rainfall data for Salima district was used to come up with planting dates using the method explained in chapter 3 section 3.4 and the generated planting dates are shown in the table below

Table 1: Planting dates and trigger rainfall amounts during 1991-2020 in Salima

YEAR	PLANTING DATE (DAY OF THE YEAR)	DAY OF THE MONTH	RAINFALL AMOUNT (mm)
1991	349	14-Dec	36.1
1992	326	21-Nov	43.7
1993	352	17-Dec	26.4
1994	347	12-Dec	47.2
1995	340	5-Dec	32.5
1996	343	8-Dec	38.1
1997	335	30-Nov	31.3
1998	341	6-Dec	48.2
1999	354	19-Dec	37.6
2000	345	10-Dec	34.1
2001	351	16-Dec	27.2
2002	348	13-Dec	33.4
2003	351	16-Dec	29.7
2004	334	29-Nov	41.3
2005	342	7-Dec	28.8
2006	345	10-Dec	35.1
2007	350	15-Dec	48.6
2008	353	18-Dec	42.1
2009	344	9-Dec	32.7
2010	329	24-Nov	25.8
2011	365	30-Dec	31.5
2012	324	19-Nov	27.6
2013	349	14-Dec	48.5
2014	357	22-Dec	30.2

2015	354	19-Dec	37.1
2016	342	7-Dec	40.6
2017	333	28-Nov	37.4
2018	342	7-Dec	25.8
2019	332	27-Nov	37.8
2020	339	4-Dec	38.8

From the table above, it can be noted that planting dates alternate between the months of November and December in Salima. Early planting can be done in late November while delayed planting can be done in late December or early January in worst circumstances as shown in the following graphs

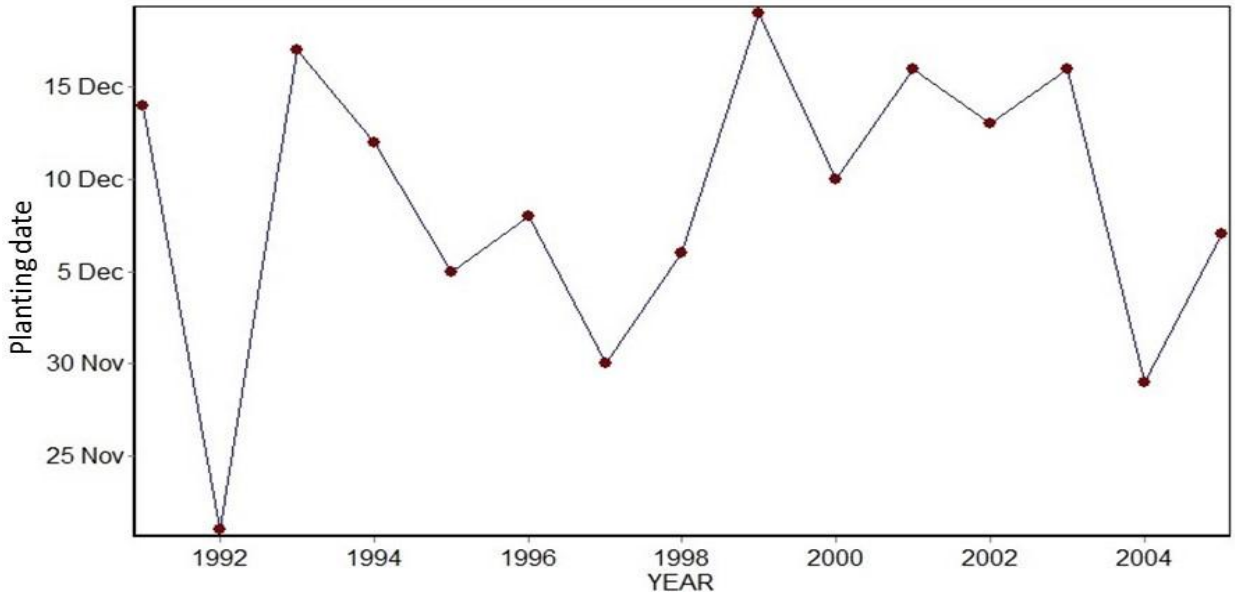


Figure 3a: Possible planting dates during 1991-2005

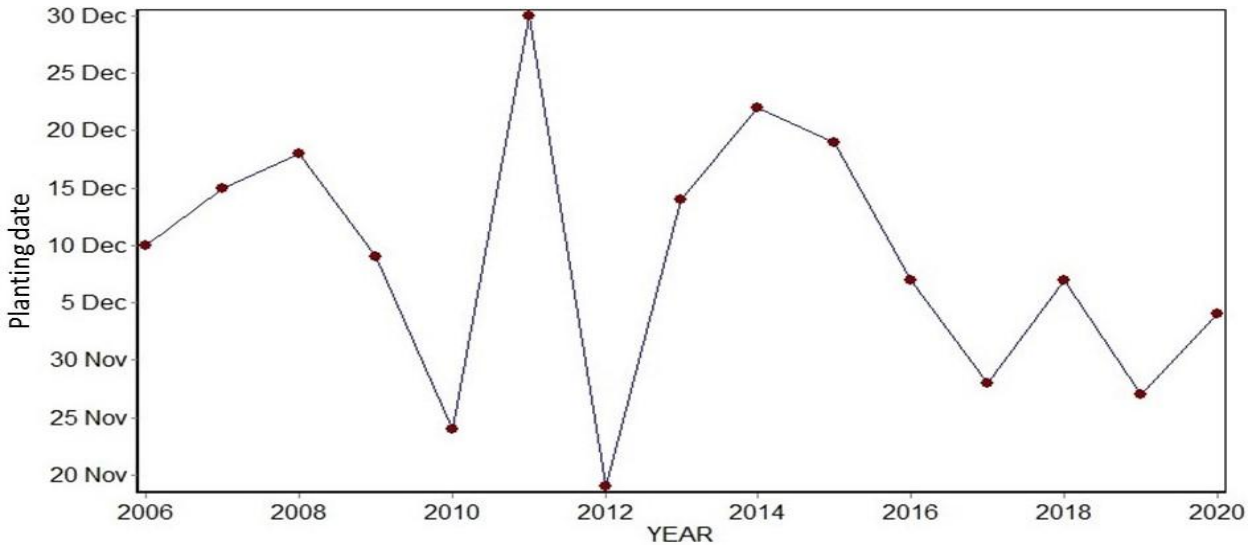


Figure 3b: Possible planting dates during 2006-2020

These planting dates generated by Instat software were closely matching the data for planting dates that was obtained from Chipoka EPA. Comparing the results with data for El Nino and La Nina years, it was found that the years in which these events were experienced there was a delay in planting with a difference in rainfall amounts that triggered planting. For example, there was a strong La Nina in 2011/2012 growing season and planting was delayed until 30 December in 2011; there was a weak El Nino in 2014/2015 growing season and planting was delayed until 22 December in 2014. Planting was also delayed until 19 December in 2015 possibly due to very strong El Nino that had hit Malawi in 2015/2016 growing season. This shows that ENSO systems have a great influence on rainfall variability and hence on planting dates. The main land use activity in Salima is rainfed maize cultivation such that these delays in planting worried many people. There is very little irrigation farming taking place in Salima including Chipoka EPA. The following map is a representation of areas where rainfed cultivation of maize is done in Chipoka and Salima in general indicated by the green contours

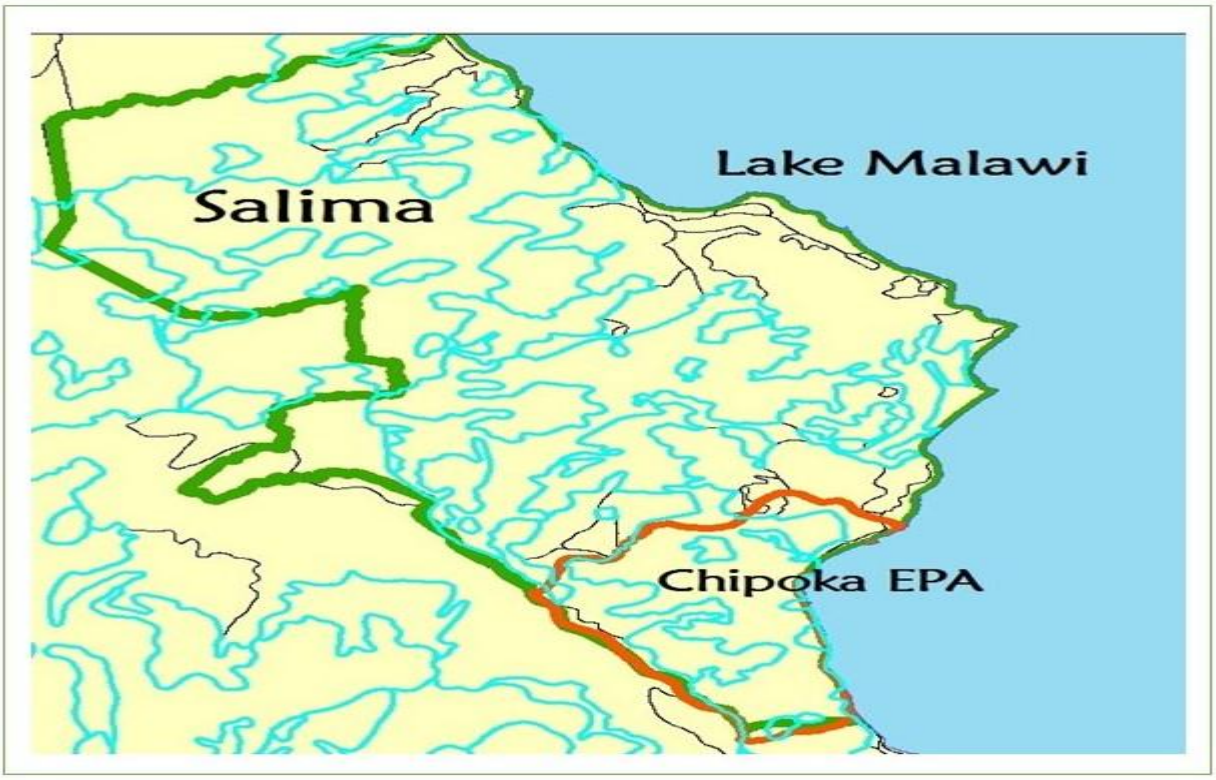


Figure 4: Map of rainfed maize cultivation areas in Salima, central region of Malawi

For the purpose of ground truthing, the generated planting dates from rainfall data were compared with the actual dates planting was done. These actual planting dates were obtained from Chipoka EPA and the comparison results showed that there was a close matching of the dates since the differences were very minimal usually of not more than four days. The differences may arise due to the following reasons:

- Deliberate delay of people to plant maize just to see if it is the true start of rainfall season.
- Early planting due to ignorance of upcoming dry spell which was avoided when using Instat.
- Distance to the nearest weather station (Salima airport) from which rainfall data was obtained.

The figure below displays the differences in actual planting dates and those which were generated from rainfall data.

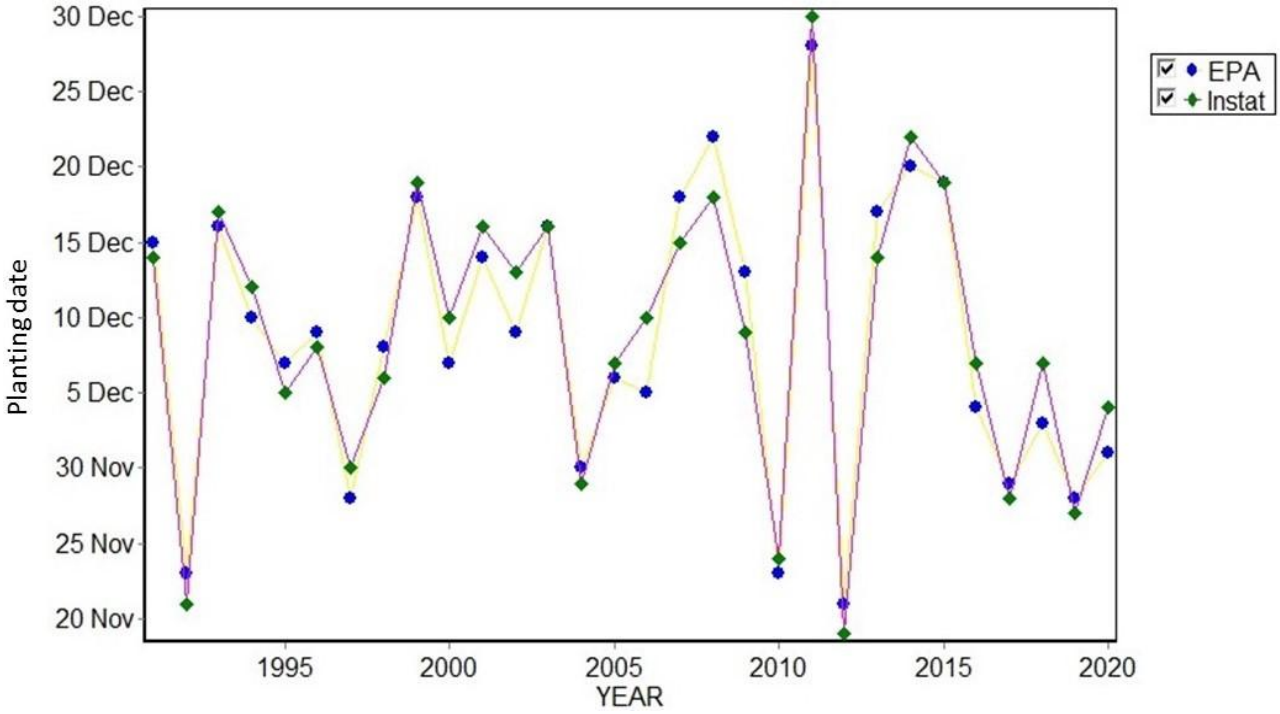


Figure 5: Chipoka EPA planting dates versus generated planting dates

4.2. Average planting date for Salima district

An average planting date was calculated by dividing the sum of all the planting dates by number of years which was 30 as explained in chapter 3 section 3.4.3. An alternative and simpler way of finding the average or mean planting date was by doing summary statistics of the planting dates using the Instat software. The results for summary statistics are shown in appendix 1. Appendix 2 presents manual calculation of average planting date.

The average or mean planting date was found to be 344 which is 9 December. Planting dates were found to have a standard deviation of 9.51 days and mean deviation of 7.73 days. Standard deviation measures dispersion of data values from the mean, it was calculated to find variability of planting dates (distance from the mean planting date). These results show that the variation is minimal. The mean deviation of 7.73 days means that on average, the planting dates are about 8 days away from the mean planting date which is just one week and a day away. Standard deviation is the result of square root of variance and was calculated by the formula:

$$\sigma = \sqrt{\frac{\Sigma(x - \mu)^2}{N}}$$

Where x is any planting date, N is the total number of years and μ is the mean planting date.

4.2.1. Classifying early, normal and late planting dates

From the standard deviation, the normal period for planting in Salima was found to be:

Mean planting date − standard deviation<mean planting date<mean planting date + standard deviation

=344− 9<344<344+9

=335<344<353

=30 NOV<9 DEC<18 DEC

This can be presented in a figure as shown below

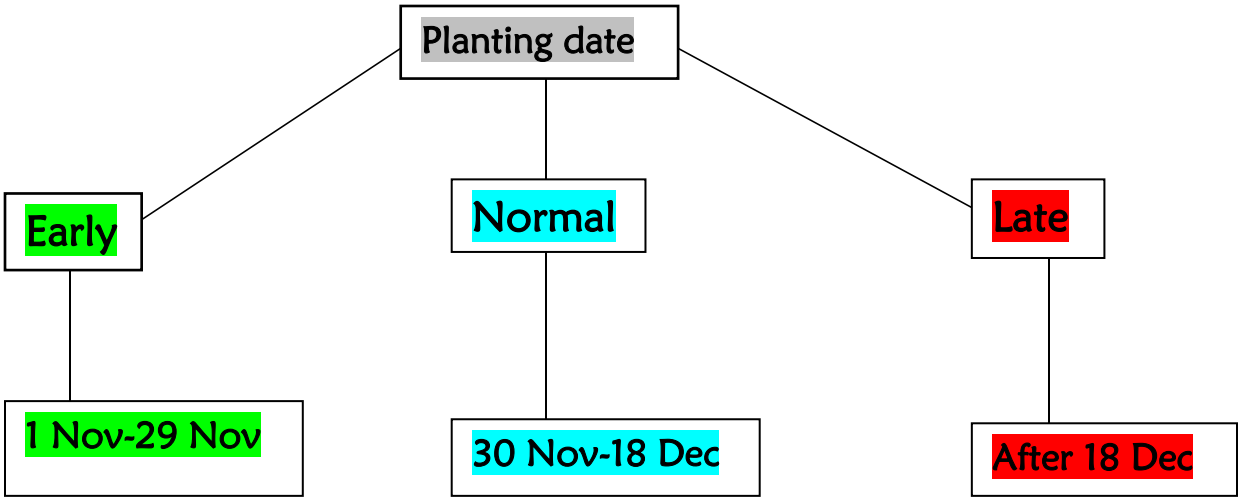


Figure 6: Illustration for classification of planting dates

Therefore, the normal or optimum planting period in Salima is between 30 November and 18 December. Planting is early if it is done before 30 November and late if it is done after 18 December. From the results, it shows that planting was done within normal and early days in many years, and there are few years in which planting dates fall within the

late group. This implies that rainfall variability in Salima is consistent with natural variability and not necessarily due to climate change since there is no noticeable shift of planting dates but only alternates within November and December. Table 2 below shows classification of planting dates for some years based on the criteria above

Table 2: Classification of planting dates for some years

Early	Date	Normal	Date	Late	Date
1992	21 Nov	1991	14 Dec	2011	30 Dec
2012	19 Nov	1993	17 Dec	2014	22 Dec
2019	27 Nov	2009	09 Dec	2015	19 Dec

4.3. Periodicity of variation in planting dates

This section intends to find out if the variation in planting dates occurs periodically. The following figure was used to make a judgement of whether the delay in planting follows a certain pattern.

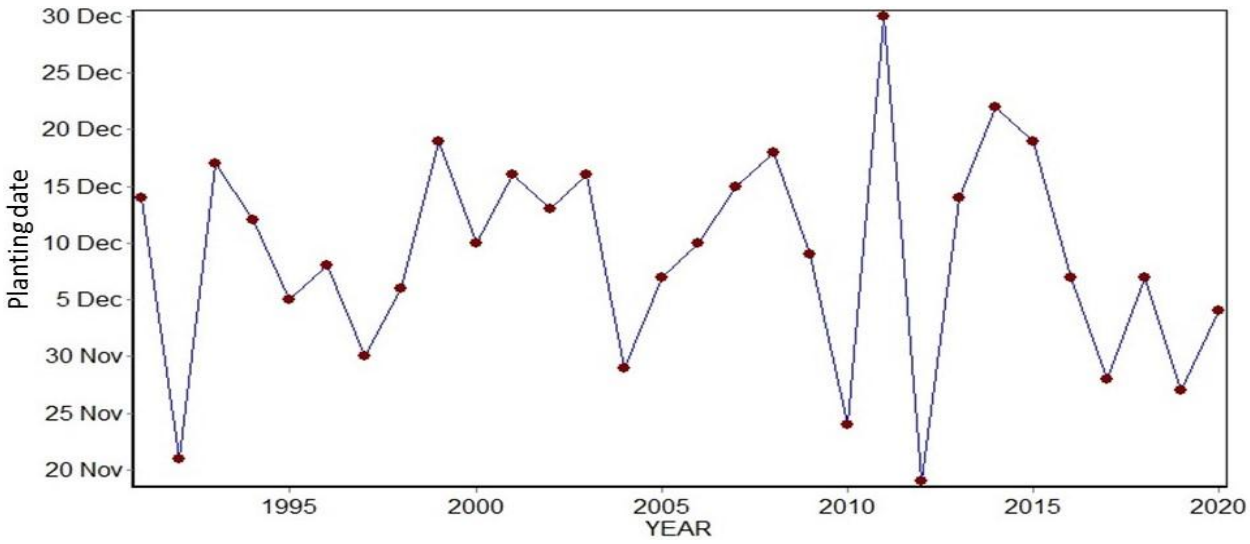


Figure 7: Possible planting dates during 1991-2020 (combination of figure 3a and 3b)

From the figure above, a conclusion which was drawn is that there is no defined pattern in terms of how planting dates fluctuate i.e., there is no visible trend hence no defined periodic pattern, but there is a high possibility of experiencing an opposite scenario in each successive growing season. That is to say, if planting is done early this season, then there is a high possibility of being late or normal in the next growing season. Hence, variability in planting dates does not happen periodically but changes due to natural factors that influence rainfall variability such as El Nino southern oscillation.

4.4. Evaluation of monthly rainfall variability

Monthly rainfall data for three stations in Salima was obtained and used to evaluate the changes in rainfall amounts from 1991 to 2020. These meteorological stations are Salima aerodrome, Chitala and Lifuwu research stations. The monthly rainfall totals did not show any noticeable and visible increase or decrease in rainfall amounts over the years; hence, the data results did not give any evidence of change in rainfall intensity for these regions and Salima as a whole. Rainfall amounts were plotted against the year in months of November, December and January as shown in the graphs below

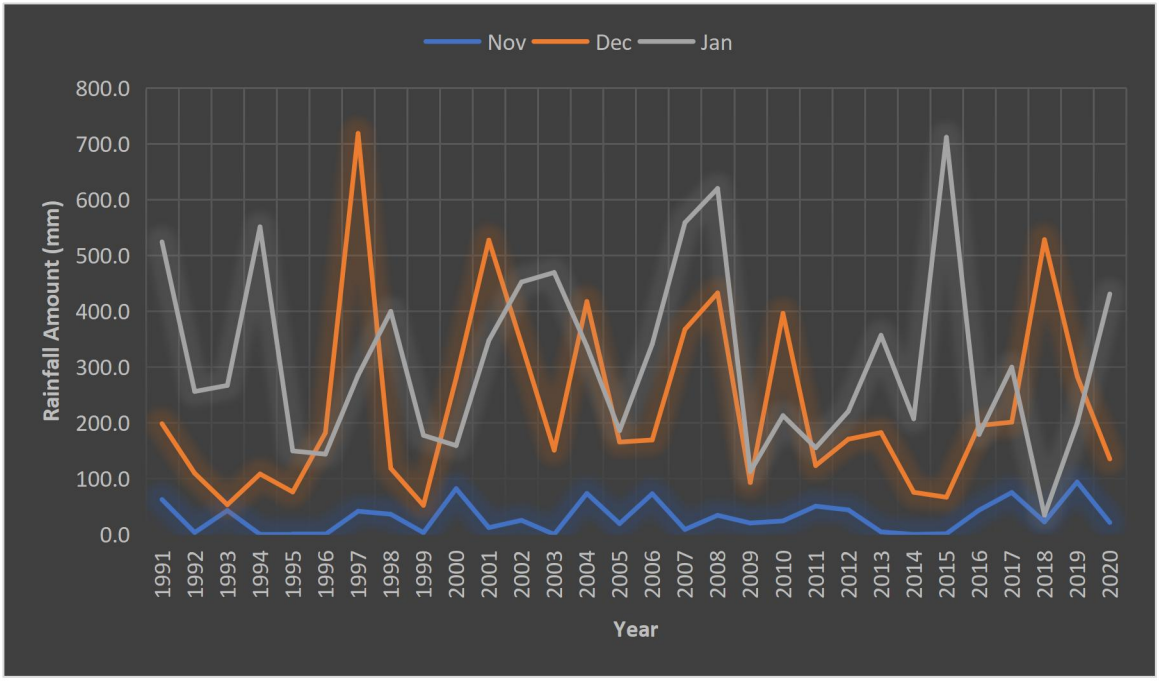


Figure 8a: Monthly variability in rainfall amounts for salima aerodrome during 1991-2020 from November to January (Data source: Salima aerodrome)

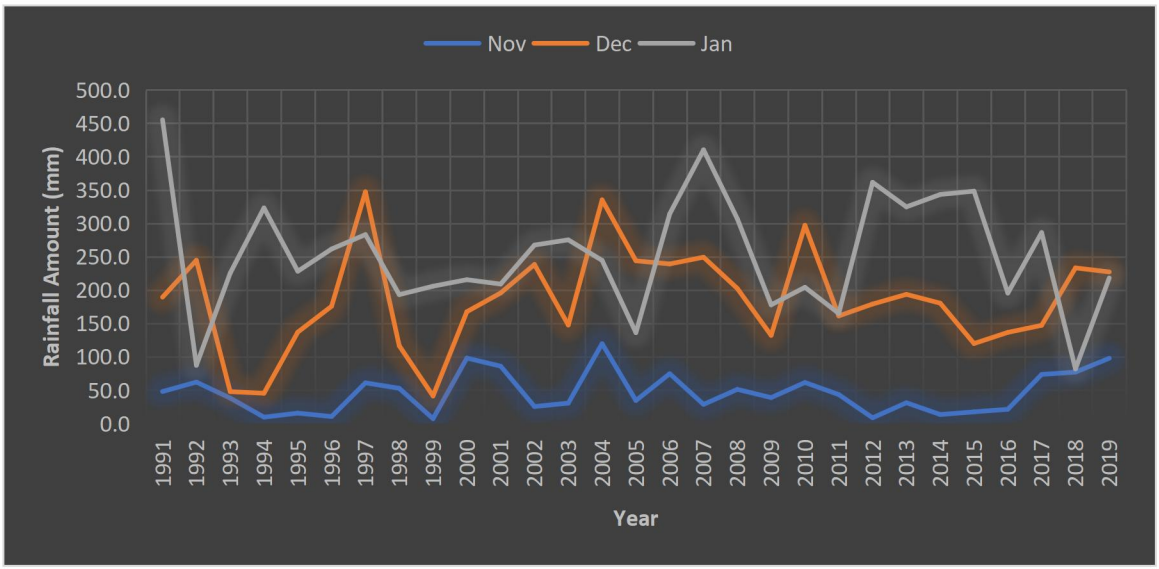


Figure 8b: Monthly variability in rainfall amounts for chitala during 1991-2019 from November to January. (Data source: Chitala research station)

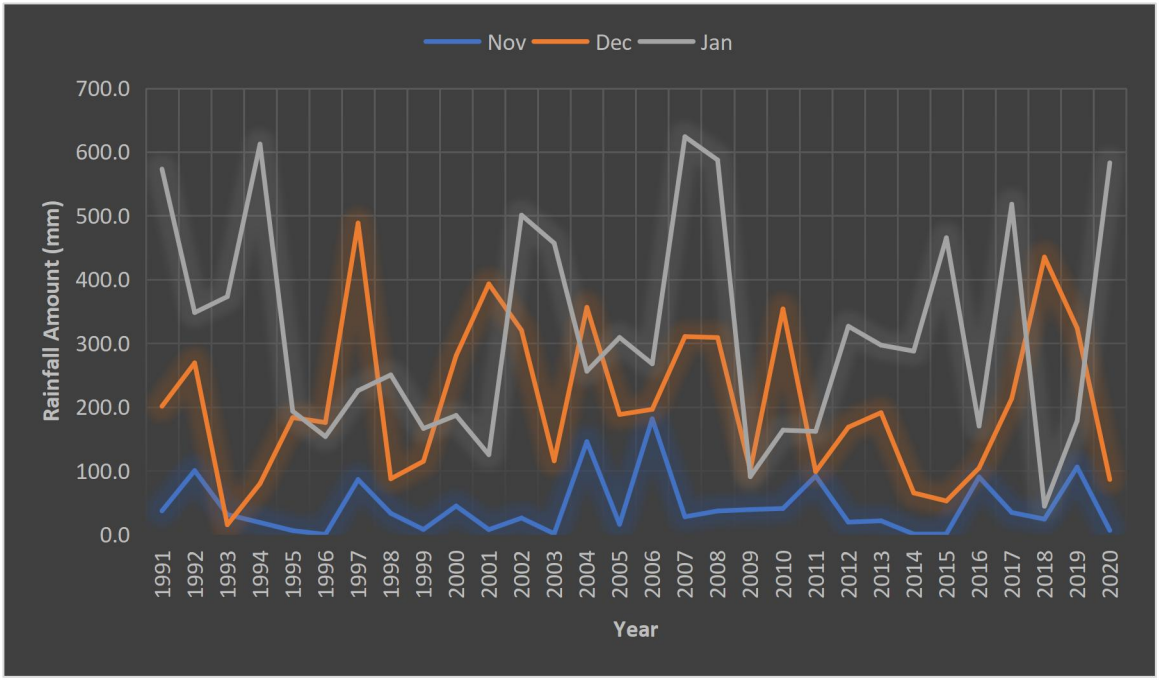


Figure 8c: Monthly variability in rainfall amounts for Lifuwu during 1991-2020 from November to January. (Data source: Lifuwu research station)

From figures 8a to 8c above it shows that some years receive more rainfall in December than in January despite January being the climax of rainfall season but it is very rare to

receive more rainfall in November than in December and January. It is also noted that it falls heavily in areas around Salima aerodrome than in areas around Chitala and Lifuwu research stations. The highest rainfall amount in Salima aerodrome was 718.8mm and was received in December, 1997 while the highest value in Chitala is 455.1mm and was received in January, 1991. The highest value in Lifuwu is 623.8mm and was received in January, 2007. There is no change in rainfall intensity but only fluctuates year to year.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.0. Summary

Rainfall variability and climate change have adverse impacts on rainfed agriculture. It is associated with early season dry spells that makes planting unsuccessful and result in replanting. This increases cost of production. Onset of rainfall season is the main determinant of shift in planting dates and time for planting. Many studies show that farmers are facing late onset of rainfall season and hence planting dates that is decreasing the duration of growing season forcing them to opt for hybrid seeds that require excessive use of chemical fertilizers to do well. This was presented in chapter 2. In this study average planting date for Salima district was determined using the method in section 3.4.3. Planting dates were calculated from daily rainfall data using a definition that included a condition that makes planting more successful by avoiding early season dry spells. This helped to come up with planting dates that are based on the true start of rainfall. Results were tabulated and then presented graphically to ease evaluation of shift in planting dates which was the main objective of the study.

5.1. Conclusion

This study examined the changes in planting dates for maize production in rainfed agriculture in Salima district. Planting dates were generated from daily rainfall data for Salima district from 1991 to 2020 using Instat plus software package version 3.37. Results showed that the normal or optimum period for planting maize in rainfed agriculture in Salima is between 30 November and 18 December. Early planting can be done before 30

November while late planting can be done after 18 December depending on the factors that influence rainfall variability.

Having knowledge of planting date helps farmers in planning for their daily activities regarding farm operations. In many developing countries like Malawi agriculture is the main reliable way of generating income for many people. Agriculture employs about 85% of Malawians that sustains their livelihoods. Therefore, climate change and rainfall variability have great implications on a large number of people and the impacts are most felt in economic sectors that depend on reliable weather patterns such as agriculture. These reliable weather patterns include steady temperature and normal and well distributed rainfall.

Malawi has savanna climate which is characterized by wet and dry seasons. Rainfall season is experienced in the months of November to April during warm-wet season. The main rain bearing system is Inter-Tropical convergence zone (ITCZ). Rainfall variability is influenced by El Nino Southern Oscillation and La Nina. Movement of ITCZ also influences the start of rainy season and planting dates since it does not follow a fixed pattern year to year.

5.2. Recommendations

The researcher recommends that further studies can evaluate end of seasonal rains and duration of rainfall season in Salima which can help to determine suitable maize varieties that can be grown in the area.

Future research can also evaluate effects of planting time on maize yield. The planting date has a significant impact on maize growth, production, and yield. For increased crop production, the best planting date is crucial. Delaying planting has a significant impact on maize plant growth, production, and productivity which can have impact on the amount of yield a farmer can get from his or her crops.

The study can also be replicated by including years long ago before 1990 but that can have a limitation of data unavailability. It can also be replicated after some years to come in the future to see if there are any changes taking place.

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APPENDICES

Appendix 1

Results for summary statistics of planting dates

Column	PD
No. of observations	30
Minimum	324
Maximum	365
Range	41
Mean	343.87
Std. deviation	9.5113
Mean Deviation	7.7333

Appendix 2

Manual calculation of average planting date

Average planting date $= \frac{\text{Sum of all planting dates (N)}}{\text{Number of years (n)}}$

$= \frac{\Sigma N}{n}$

ΣN=349+326+352+347+340+343+335+341+354+345+351+348+351+334+342+345+350+353+344+329+365+324+349+357+354+342+333+342+332+339

=10316

n=30 years

Average planting date=$\frac{10316}{30}$ = 343.8667 = 344 = 9 December